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THE PRODUCTION AND FIELD TESTING OF CANCOAT DRAGGER SHOES

K.G. DAVIS
FOUNDRY SECTION

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MINERALS RESEARCH PROGRAM

PHYSICAL METALLURGY RESEARCH LABORATORIES
REPORT: MRP/PMRL 82-31(TR)

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by

K.G. Davis

ABSTRACT

This report describes the production and subsequent field testing of certain castings with wear-resistant surfaces placed on by the CANCOAT procedure developed at PMRL. Twelve trawl-door dragger shoe castings made of ductile iron with CrC hardfacing were made at Canron Inc., Burlington, Ontario, under contract to Supply and Services Canada. Some of these castings were tested in fishing trials and their performance compared with standard steel shoes. This work was carried out under a second SSC contract with Industrial Marine Products Ltd., Dartmouth, N.S. It was demonstrated that the CANCOAT procedures are readily adaptable to commercial production. However, the hardfaced castings showed no improvement over the standard castings in the particular application chosen.

INTRODUCTION

The CANCOAT procedure for the 'in situ' production of castings with wear-resistant surface layers has been described elsewhere.* It is based on the use of a vacuum to hold a layer of abrasion-resistant powder on the surface of a mould cavity. When the cavity is filled with liquid metal, the vacuum promotes infiltration of molten metal through the powder and eliminates gas defects that plague similar approaches where vacuum is not used. Three contracts administered by Supply and Services Canada have been involved. Intersteel Consultants Ltd., Willowdale, Ontario, did a cost and marketing

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* "cast-in-place hardfacing", PMRL report MRP/PMRL 80-90(J).

analysis on the process (DSS 3115-8-0739). They identified "dragger shoes" used in fishing operations by trawlers as a casting type suitable for possible application of CANCOAT. These castings are fitted to the bottom edges of the trawl doors that keep the nets in position. Each trawl door has three such shoes. The doors weigh up to 3300 lb (1500 kg), so wear on the bottom edges is severe. The shoes are normally replaced every two to six weeks, depending on the nature of the sea bed. It is estimated that replacement of dragger shoes costs Canada's East Coast fishing fleet about $2.5 million each year. Current shoes are made from a medium-manganese carbon steel, and most are imported.

It was decided to test a ductile iron shoe with a CANCOAT layer of CrC on the bottom surface. A ductile iron casting is cheaper than an equivalent casting made of steel, which will offset the extra cost of the hardfacing to a degree. Further, the combination of CrC on a ductile iron base has been shown to give good abrasion-resistance in laboratory tests for low-stress and high-stress abrasion conditions, see Table 1, 2. The abrasion resistance of this combination was found in these tests approximately equivalent to a "15/3" Cr-Mo white iron, one of the hardest-wearing of the abrasion-resistant irons.

Designs for a centre dragger shoe were obtained from Industrial Marine Products Ltd., Dartmouth, N.S., hereafter referred to as "IMP". The casting was approx. 34 in. long by 5 1/4 in. wide by 2 in. thick (86.4 x 13.3 x 5.0 cm), with some curvature along its length, and weighed about 65 lb (29.5 kg). Pictures of cast shoes may be seen in Appendix 1.

Tests done at the PMRL Foundry

Test castings with cross-section and curvature similar to the dragger shoes were made in the PMRL experimental foundry to determine suitable materials and coating procedures. They were 2 1/2 in. by 5 in. by 11 in. (6.4 x 12.7 x 27.9 cm). An example is shown in Fig. 1. Vacuum cores were designed to give a 1/8 in. (3.2 mm) powder layer, overlapping the largest (curved) surface of the casting by approximately 1/2 in. (12 mm). Figure 2 gives a general idea of the mould design. The mould had an opening into which the vacuum core was lowered to define one (vertical) wall of the casting. The castings were all of ferritic ductile iron, except for one made of an AISI 1020 steel. Three designs of vacuum core were tested, made from either cast iron, welded steel plate, or CO_2-sand with a steel backing plate. The most

consistent results were obtained using a fabricated steel plate design, with a layer of fine unbonded zircon sand under the CrC powder.

Figure 3 shows a vertical section through the centre of a CrC-coated ductile iron casting. The ingate can be seen on the lower left. There was some dilution of the CrC, and also a tendency for the coating material to float toward the top surface. The coating was however continuous, with a mean thickness around 3/8 in. (9.5 mm). In addition to loose, fine CrC powder, layers of granular CrC pre-bonded with either ethyl cellulose or citric acid were also tested. Results were inconsistent. The surface layer often contained blowholes, and there was a tendency for the CrC to be washed away from the surface opposite the gate. An example of the latter is shown in Fig. 4. A total of 22 test castings were made. It was decided to contract out the production of 12 CANCOAT middle dragger shoes in ductile iron with a CrC coating. The vacuum core was to be made from steel plate.

Castings made by Canron

The castings were made, under contract, at Canron Ltd., Burlington, Ontario. Their summary report comprises Appendix 1. Twelve satisfactory castings were produced from the sixteen made. Figure 5 shows the castings as they were received in Ottawa. A few points with respect to these castings and the Canron report may be noted:-

1) The lugs for mounting steel shoes onto the trawl doors are welded onto the shoes. With ductile iron they were cast as an integral part of the shoe, as can be seen on p. 6 of Appendix 1, and in Fig. 5(c).

2) Data from the test castings made at PMRL showed that CrC powder usage was approx. 0.023 lb/in.^{2} (1.8 g/cm^2). Canron reports a usage of 8.75 lb (3.97 kg) per shoe. The coated area of the shoes was about 179 in.^{2}, and so the usage rate was 0.049 lb/in.^{2}, about twice that expected. Experiments at PMRL with larger vacuum cores, after the Canron work, have shown that the perforated metal forming the vacuum manifold behind the sand in the core flexes when vacuum is applied. This causes cracking of the CO_2 sand covering the manifold, allowing powder to leak into the manifold. Canron mention 'sealing problems', which should not occur. It is likely that in the Canron tests powder was lost due to the above effect. It also explains the "local areas of poor penetration" observed by Canron, which would correspond with areas where CrC powder blocked the pores in the CO_2 sand. A fairly simple design

change has been incorporated in a recent series of CANCOAT castings. The manifold was made external to the core so any flexing would leave the sand undisturbed. CrC usage with this design averaged 0.024 lb/in.^{2}, and the metal penetration into the powder layer was consistently satisfactory.
3) Figure 6 shows a section through one of the Canron shoes. It is clear that extensive dilution of the CrC has taken place. Hardness traverses show Rc values up to 60 in the surface region (Fig. 7). There were some regions of softer material within the surfacing. It may be noted that typical high-chromium cast iron weld hardfacings for severe wear conditions have Rc hardnesses of 55 to 60 (see for example Table 3), so reasonably good wear resistance may be expected from the CANCOAT castings.

Field testing of the Canron dragger shoes

Under the management of IMP (SCC contract Serial No. 0SQ80-00109), three of the middle dragger shoe castings made by Canron were fitted to trawlers and tested in fishing trials. Standard dragger shoes with composition 0.29% C, 0.02% S, 0.023% P, 0.55% Si, 1.68% Mn, plus traces of Cu, Ni, Cr, V, were run in parallel with the test shoes, i.e. test shoe on the port trawl door, standard shoe on the starboard trawl door (or vice-versa). The grade of ductile iron used by Canron had a pearlitic matrix and some primary carbides. It was probably close to an "80-55-06" grade. Its Brinell hardness was around 250. In an attempt to increase the ductility of one shoe, it was given the following ferritizing treatment. Hold 8 h at 1650°F, cool in furnace to 1325°F, hold at 1325°F for 18 h, cool at approx. 35°F/h to 1000°F, and furnace cool to room temperature. Brinell hardness after this treatment was approx. 180. A fully ferritic structure was not obtained; the final matrix structure had coarse, globular pearlite with ferritic regions around the graphite nodules. This shoe broke into three pieces shortly after being put into service. Two portions were returned to PMRL for examination, where cracks were noted on the coated surface. One piece was deliberately fractured at the position of one of the cracks. It was clear that a deep crack had been present before the sample was fractured, (Fig. 8). It appears that, despite the slow cooling rates used in the heat treatments, cracking took place at that time.

The field tests done under the direction of IMP are described in their report incorporated here as Appendix 2. The standard and CANCOAT shoes

were shipped to PMRL after testing. They are shown in Figs. 9 and 10. It may be noted that:-

1) Wear is concentrated on one edge of the shoes at the front.
2) Wear is greater on the CANCOAT shoes.
3) One of the CANCOAT shoes was fractured. This must have taken place after completion of the fishing trials because there is no rounding of the crack edge.

Figure 11 shows cross-sections of the standard and CANCOAT shoes cut near the end where the wear was severe. There is no evidence of any preferential wear resistance on the CANCOAT cross-section where CrC-rich material joins the ductile iron. It must be concluded that these shoes are subjected to extremely severe wear conditions. It should be noted that while this material gave very good resistance to wear in the laboratory tests, it cut with ease on the large abrasive wheel used in preparing the wear-test specimens. It may also be noted that the loading per unit area in the laboratory high-stress abrasion tests was comparable to that on the dragger shoes. The severe wear on the shoes may, therefore, come from their greater velocity. Trawlers operate at about 2.3 m/s (4.5 knots, or 7.6 ft/s), whereas in the high-stress abrasion tests the sample moves relative to the track at about 0.5 m/s (1.6 ft/s).

Considering that wear takes place on one edge of the shoes, it is doubtful if any form of hard-facing would be effective for this application. Even if wear is slow in the initial stages when the hard-facing at the corner is being removed, the rate will speed up as more of the softer matrix material is exposed. At the stage of wear shown in Fig. 11(b), for example, the wear surface is about 2/3 ductile iron.

In trying the CrC/ductile iron combination for dragger shoes, we clearly underestimated both the impact loading to which these parts are subjected, and the severity of the wear conditions. The present results should not discourage further testing of CANCOAT, but will serve to illustrate that areas of application have to be chosen with care.

Final comments

The main value of the project has been to demonstrate that CANCOAT castings can be made in a commercial foundry. Some changes in the vacuum core design will be made in any future work. The choice of application proved

to be inappropriate. It does however serve to demonstrate, once again, the delicate dependence of wear resistance on the specific conditions of wear. A test involving rapid movement between sample and abrasive, in an aqueous environment, under high loading, will have to be developed if candidate wear-resistant materials are to be ranked for use on dragger shoes.

ACKNOWLEDGEMENTS

The contributions of Fred Koch, Canron Inc., who supervised the production of the shoes and wrote Appendix 1, and of Jim Lobban, IMP Ltd., who arranged for and supervised the fishing trials and wrote Appendix 2, are gratefully acknowledged.

Table 1. Results of low-stress abrasion tests on samples cut from drop-weight test-plate castings. Vacuum-core technique. Test performed by Falconbridge Metallurgical Laboratories. 15.5 kg load, AFS 50/70 silica sands. 5 min. intervals. Abrasion-resistance factor = weight loss of mild steel sample/weight loss of test sample.

Casting alloy	Coating material	U.S. sieve range	Abrasion-resistance factors	Av.
AISI 4340 steel	WC-10% Co	-325	25.4, 28.0, 22.4	25.2
Ductile iron	Cr carbide	-230	18.4, 19.7, 17.5	18.5
AISI 4340 steel	Cr carbide	-230	16.3, 15.6, 15.3	15.7
AISI 4340 steel	W carbide	-40 +100	8.9, 11.5, 11.4	11.4
AISI 1020 steel	Cr carbide	-230	10.2, 10.3, 10.2	10.2
Ductile iron	WC-10% Co	-325	6.5, 5.0, 4.6	5.3

Table 2. Results of high-stress abrasion tests on samples cut from drop-weight test-plate castings. Tests performed by Falconbridge Metallurgical Laboratories. 28.2 kg. load, AFS 50/70 silica sand, 10 min intervals. Abrasion-resistance factor = weight loss of mild steel sample/ weight loss of test sample.

Casting alloy	Coating material	U.S. sieve range	Moulding technique	Abrasion-resistance factors
Ductile iron	Cr carbide	-230	Vacuum-core	1.76, 1.56
Ductile iron	Cr carbide	-230	Vacuum-core	1.40, 1.31
AISI 4340 steel	Cr carbide	-230	Vacuum-drag	1.37, 1.47
12% Mn steel	WC-10% Co	-325	Vacuum-core	1.29, 1.27
AISI 4340 steel	Cr carbide	~80	Vacuum-core	1.17, 1.19
AISI 4340 steel*	Cr carbide	-230	Vacuum-core	1.07. 1.12
AISI 4340 steel	W carbide	-40 +100	Vacuum-drag	1.14, 1.00
AISI 4340 steel	WC-10% Co	-325	Vacuum-core	1.07, 0.99
AISI 4340 steel	WC-10% Co	-325	Vacuum-core	1.01, 1.03
6-1 Mn/Mo steel	Cr carbide	-230	Vacuum-core	1.05, 0.97
AISI 1020 steel	WC-10% Co	-325	Vacuum-core	0.74, 0.68
AISI 1021 steel	Cr carbide	-230	Vacuum-core	0.71, 0.75
AISI 1020 steel	WC-10% Co	-325	Vacuum-core	0.52, 0.55
AISI 1020 steel	W carbide	-40 +100	Vacuum-core	0.41, 0.50
AISI 4340 steel	Corundum	-30 +70	Vacuum-core	0.42, 0.44
Ductile iron	WC-10% Co	-325	Vacuum-core	0.34, 0.36

*Test sample cut from 50 mm-thick plate casting.

Table 3. From advertisement in the "Australian Welding Journal".

Alloy base and trade designation	Hardness Rockwell†	Available forms	Nominal chemical compositions per cent††	Descriptions
HAYNES IRON-BASE ALLOYS				
Multipass	C-28	B	Cr-2.0, C-0.10, Si-0.40, Mn-0.9	
Multipass-O (HA-14)	C-34	D	Cr-0.60, C-0.20, Si-1.4, Mn-2.0, Mo-0.4	
Multipass-S (HA-4)	C-31	C	C-0.10, Si-0.35, Mn-1.9, Mo-0.4	
5	C-42	B	Cr-2.5, C-0.20, Si-0.80, Mn-2.0, Mo-0.3, Others-1.0	
5-O (HA-15)	C-44	D	Cr-3.5, C-0.10, Si-0.30, Mn-2.0, Mo-0.2, Others-1.0	BUILD-UP & LOW ALLOY severe impact, light abrasion
5-S	C-43	C	Cr-3.0, C-0.15, Si-0.60, Mn-2.0, Mo-0.4, Others-1.0	
6-S	C-40	C	C-0.10, Si-0.90, Mn-2.0, Mo-4.5, Ni-5.0, Others-1.0	
7-S	C-38	C	Cr-2.2, C-0.10, Si-0.40, Mn-2.2, Mo-0.4, Others-1.0	
Ni-Mang	B-88, C-44*	B	Cr-2.5, C-0.60, Si-0.20, Mn-13.5, Ni-3.0, Others-1.0	
Ni-Mang-O	B-86, C-44*	D	Cr-3.8, C-0.60, Si-0.40, Mn-14.5, Ni-3.4, Others-1.0	Work-hardening manganese steels
Sta-Mang	C-10, C-46*	B	Cr-16, C-0.70, Si-0.30, Mn-15, Mo-0.3, Ni-12, Others-1.0	severe impact, moderate to light abrasion
Sta-Mang-O	C-19, C-48*	D	Cr-13, C-0.30, Si-0.30, Mn-15, Mo-0.1, Ni-1.4, Others-1.0	
HASCROME alloy	C-26, C-43*	B	Cr-12, C-1.25, Mn-3.0	
11 (H-1)	C-57	B	Cr-15, C-3.9, Si-1.4, Mn-1.0, Mo-0.4, Others-1.0	
11-O (HA-1)	C-52	D	Cr-16, C-3.5, Si-1.0, Mn-1.3, Mo-0.5, Others-1.0	General purpose and maintenance
32	C-57	B	Cr-6.8, C-0.80, Si-0.30, Mn-1.4, Others-1.0	
32-S (HA-2)	C-52	C	Cr-5.4, C-0.40, Si-0.90, Mn-3.0, Mo-0.8, W-1.4, Others-1.0	moderate impact, moderate abrasion
9[illegible]	C-47	B	Cr-2.6, C-2.5, Si-0.35, Mn-1.2, Others-2.0	

Table 3. continued

Alloy base and trade designation	Hardness Rockwell†	Available forms	Nominal chemical compositions per cent††	Descriptions
HAYNES IRON-BASE ALLOYS				
420-S	C-54	B	Cr-12, C-0.30, Si-1.0, Mn-2.0, Others-1.0	
Crusher	C-57	B	Cr-22, C-4.1, Si-0.10, Mn-0.10, Mo-0.30, Others-1.0	
Crusher-0 (HA-CR)	C-55	D	Cr-23, C-3.2, Si-0.20, Mn-0.10, Mo-0.2.0, Others-1.0	
92	C-64	A	C-3.75, Mo-10	
93	C-62	A	Cr-17, C-3.0, Mo-16, Co-6.3, Others-2.0	Severe wear
93	C-57	B	Cr-17, C-3.0, Mo-16, Co-6.3, Others-2.0	light to moderate impact, severe abrasion
94	C-58	B	Cr-31, C-3.5, Si-0.75, Mn-1.2, Mo-1.0, Others-2.0	
94.0	C-56	D	Cr-27, C-3.25, Si-0.95, Mn-0.75, Co-3.0, Others-3.6	
94-G	C-61	E	Cr-29, C-2.3, si-1.4, Mn-1.0, Others-1.0	

NOTE: Hardness of A-91 for composite rods and HAYSTELLITE is hardness of the tungsten carbide particles.

† Bare Rods (one layer deposit) Covered Electrodes and Open-Arc Tube Wires (two-layer deposit) and Sub-Arc Tube Wires (three layer deposit).

††Composition of rod or undiluted deposit.

*Work Hardened

**For Gas Tungsten Arc Only

Fig. 1. Example of the test castings made at the PMRL foundry. CrC on ductile iron. The coated surface is shown at the front. (neg 2117)

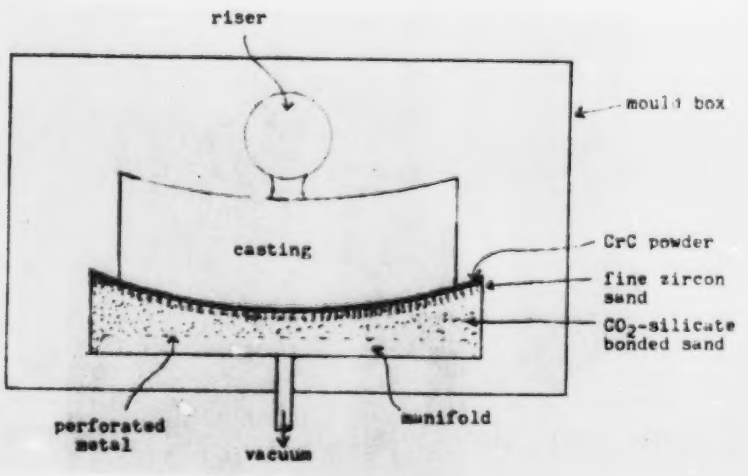


Fig. 2. Schematic of the mould layout for the test castings. Welded steel vacuum core.

Fig. 3. Vertical section through a test casting. Loose CrC on ductile iron. Coated surface on right. Shown in the same position as in the mould, gate at lower left. (neg 2318)

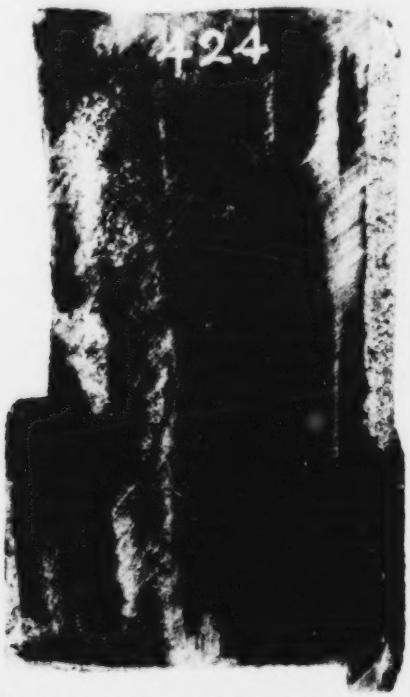
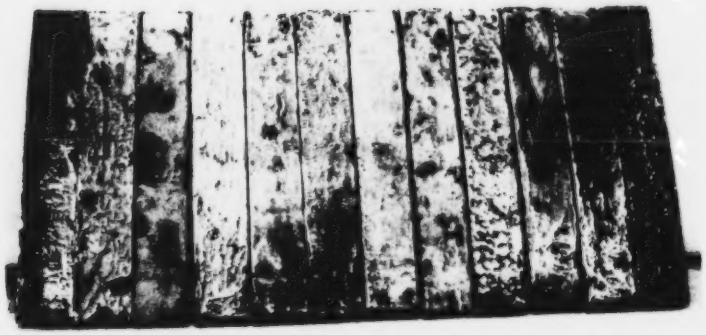
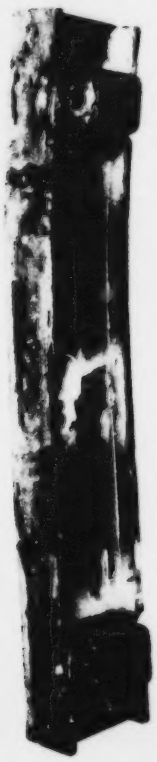


Fig. 4. Vertical section through a test casting. CrC on ductile iron. Bonded CrC grain. Shown in the same position as in the mould, gate at lower left. (neg 2319)



(a) (neg 3453)

(b) (neg 3455)



(c) (neg 3456)

Fig. 5. Examples of the dragger shoe castings made at Canron. (a) the top surfaces. (b) and (c) views from the top and bottom respectively of a casting.

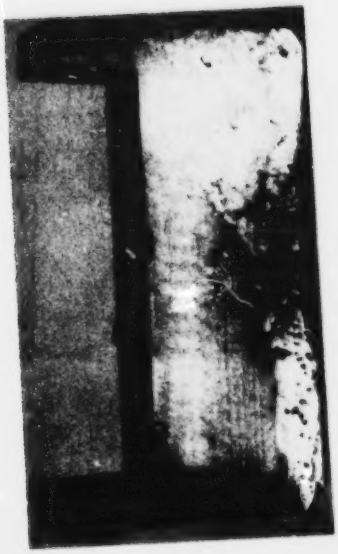


Fig. 6. Section through a Canron dragger shoe casting. CrC on ductile iron (neg 3592)

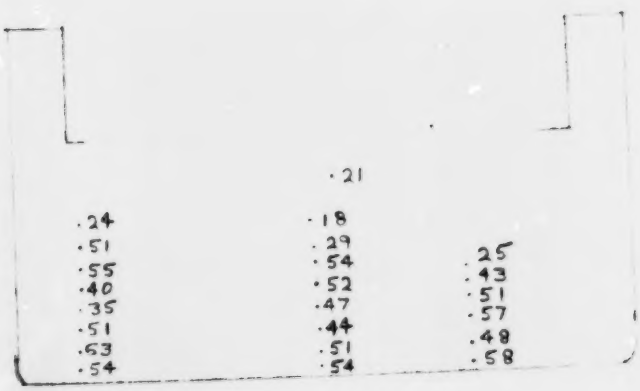


Fig. 7. Hardness traverses on a section through one of the Canron dragger shoes. Values are in Rockwell C. Half actual size.

Fig. 8. Fractured surface of the heat-treated dragger shoe. The original cracks show up dark on the lower (coated) surface. The porous region at the top of the picture comes from shrinkage around the attachment lugs. (neg 4591)

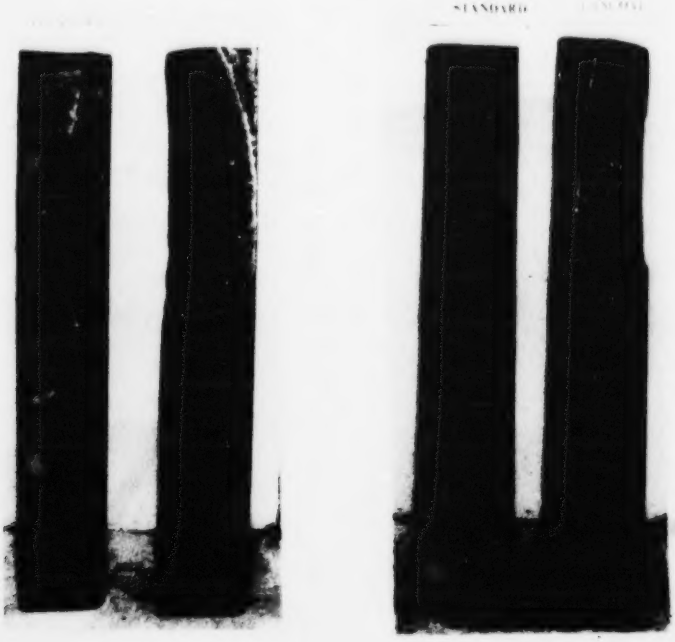


Fig. 9. Standard and CANCOAT dragger shoes after sea trials, viewed from their bottom surfaces. (negs 6306 and 6308)

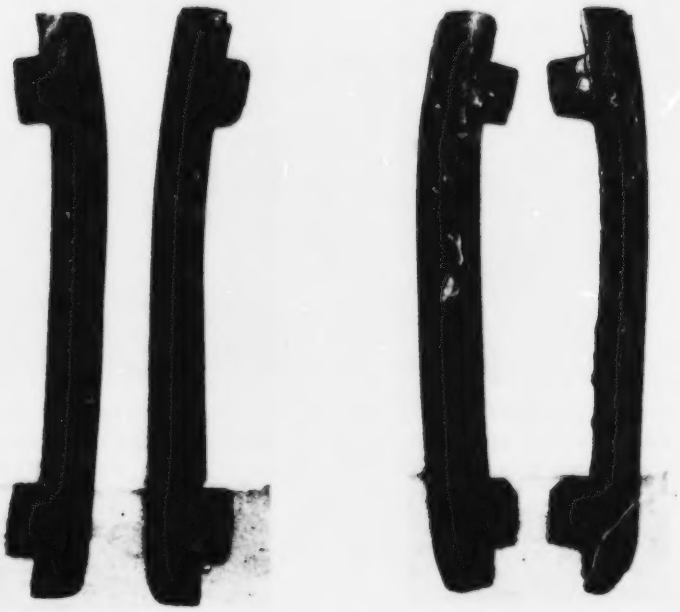
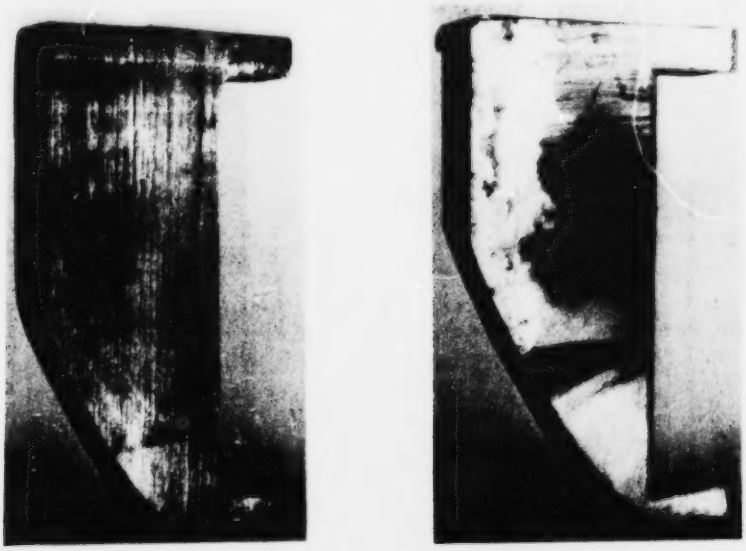


Fig. 10. Standard and CANCOAT dragger shoes after sea trials, viewed from the side. (negs 6307 and 6305)



(a) (neg 6401) (b) (neg 6400)

Fig. 11. Sections taken from the worn regions of (a) a standard and (b) a CANCOAT dragger shoe casting after sea trials.

APPENDIX 1

Canron summary report on CANCOAT dragger shoe production.

CANCOAT PROCESS

DRAGGER SHOE PRODUCTION

The initial dragger shoes produced were a learning process regarding the mechanics involved in the case of the vacuum manifold and CrC powder. It became obvious that modification to the vacuum manifold was necessary for several reasons.

The thickness of metal used to make the manifold needed to be substantially thicker in order to reduce flexing when moving the assembled core, and thus reduce disturbance of the CrC powder layer prior to pouring. This resulted in a very heavy assembly, making the insertion of the manifold into the mould cumbersome.

Increase in the amount of overlap between manifold and mould eased shakeout and reduced the incidence of flashing adherence to manifold.

Maintaining a good seal between sand and manifold was a problem area, and was overcome by the insertion of cope seal between the CO_2 portion of the manifold and the manifold. Without this localized area being sealed, metal would be sucked in at the edges to the extent that metal penetrated well into the metal - CO_2 sand interface area of the manifold.

Due to the sealing problems, full vacuum was not applied during production of the initial shoes. This resulted in incomplete penetration and a wavy surface. When full vacuum was used, a more complete penetration was achieved. However, we are at a loss to explain localized areas of poor penetration and, in some cases, no fusion at all.

CrC powder consumption was higher than anticipated; 140 lbs. of powder were consumed to produce 16 shoes. This is 8.75 lb. CrC powder per shoe. This amount of CrC at a present price of $6.88 U.S./lb. or $8.11 cost/lb. represents approximately $71.00 per shoe powder cost. This is 42% higher than estimated.

Several cross sections were cut from a dragger shoe. The white iron layer formed was much thicker than the expected ¼". The affected layer was an average 3/8" to ½" thickness. However, it was not of uniform thickness and wash-floatation effects were noticed at gate areas despite the use of a non-pressurized gating system.

GENERAL COMMENTS

Results produced are subject to a wide range of interpretation, which is dependent upon ones expectation of final quality; i.e., consistency of coating finish and depth.

To achieve complete fusion and even penetration of the CrC powder layer consistently still requires more work in particular, to manifold design. However, for products where uniformity is not critical, the process is at the stage for full scale commercial implementation.

The main area of concern is the manifold. It is possible to modify flask and pattern to allow insertion of the manifold in this application into a closed mould. Thus, the system at present would be capable of disposing a complete heat. This would result in a wide range of pouring temperature and may well interfere with consistency of results.

The system seems most suited to existing V process equipment since the vacuum pump and associated equipment cost would not have to be justified for the particular product line. Development of a suitable binder to hold the compacted powder in place in order that the vacuum need only be applied shortly prior to pouring would greatly increase the flexability and adaptability of this system.

Actual production costs have not been projected; however, the $71.00 powder cost as well as increased manufacturing cost needs to result in a significant increase in performance in order to justify acceptance on a cost/performance basis.

We are very interested in the comparative application test you will be carrying out, and are most anxious to view the results of these tests.

APPENDIX 2

IMP report on fishing trials of the CANCOAT dragger shoes.

TITLE: FIELD EVALUATION OF CANCOAT ABRASION-RESISTANT DRAGGER SHOES

FINAL REPORT

BY

I.M.P. GROUP LTD.

WORK ON THIS PROJECT WAS CONDUCTED UNDER THE AUSPICES OF THE CANADA CENTRE FOR MINERAL & ENERGY TECHNOLOGY; ENERGY, MINES & RESOURCES, CANADA.

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D.S.S. CONTRACT SERIAL NO.:	0SQ80-00109
CANMET PROJECT NO.:	0-9025
CANMET SCIENTIFIC AUTHORITY:	DR. K.G. DAVIS, DEPT. OF ENERGY MINES & RESOURCES, CANMET, PHYSICAL METALLURGY LAB., OTTAWA
DATE: 8 Mar. 82	MARCH, 1982

The sea trials of the Canmet dragger shoes were carried out on H.B. Nickerson & Sons, Ltd. deep sea trawlers.

The first pair of door shoes (IMP-4 and DSS-4HT) were installed on January 10, 1981, on the MV W.R. RITCEY, which proceeded to fish in Area 2J (off Labrador). The DSS-4HT shoe was broken into three pieces after four hours of fishing, on January 20; the sea bed in this area is classed as "fair to moderate" and includes some large rocks. It is assumed that the shoe was broken due to the trawl door striking such a rock.

In order to continue the fishing, another standard shoe was fitted at sea and the trawler continued to operate for a further 24 days, after which the I.M.P. shoe IMP-4 had to be replaced. Some fishing was carried out during the return trip, in Area 3PS, where the bottom conditions are quite similar to those in Area 2J.

The DSS-4HT shoe was broken into three pieces and the centre piece was lost on the bottom. The other two pieces were retained by the rivets in the door and were subsequently removed and returned to Dr. K. Davis. It was noted that some surface cracking had also occurred which may not have been associated with the blow which broke the shoe.

The second pair of shoes (IMP-1 and DSS-1) were installed on February 1, 1981, and went to sea on the MV BEDEQUE, which fished for 15 days in Area 4VSW and 7½ days in Area 4X. Of these two areas, 4X is the most severe, in that the bottom conditions lead to fairly rapid deterioration of the shoes. It contains some very hard bottom and some mud. Both the DSS shoe and the IMP shoe had to be replaced after these 22½ days of fishing.

The third pair (DSS-2 and IMP-2) were installed on the MV EGMONT on February 14, 1981, and both were replaced after 34¼ days of fishing (16 3/4 days in Area 4VSW and 17½ days in Area 4X). The sea bed in Area 4VSW consists mainly of sand and gravel.

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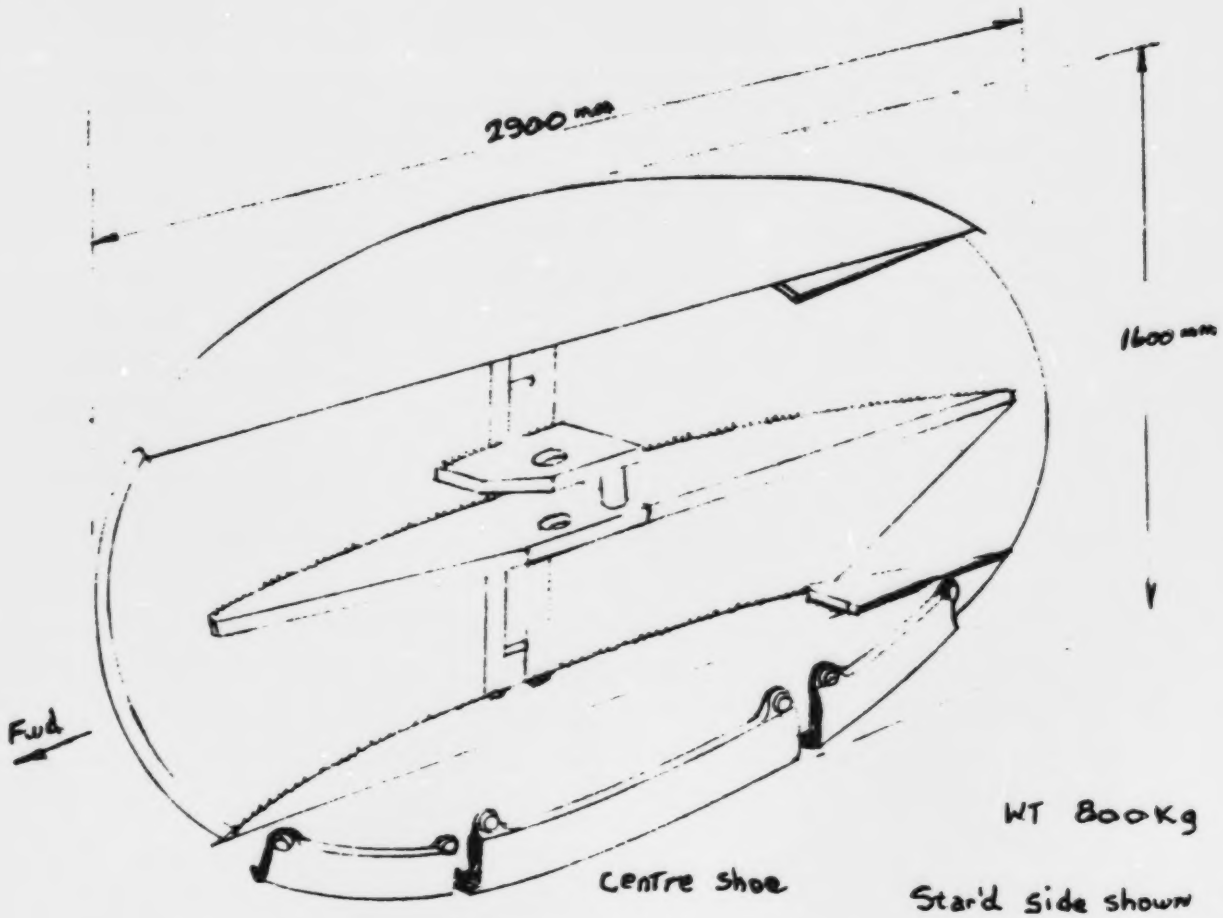
The fourth pair (DSS-3 and IMP-3) were installed on MV HILLSBOROUGH on March 5, 1981, and replaced on May 1, 1981, after 33 days of fishing. Again both shoes required replacement. Actual usage was 9 days in Area 4VSW, 8 days in Area 3PS (sand, gravel & some stone) 8½ days in Area 4VN (mud and rock), and 7½ days in Area 4X.

In the second, third and fourth pairs both shoes were worn down to replacement point at the same time with no indication of significant advantage to either shoe in terms of total usage available.

Due to the fact that the company owning the ships used in the trial inadvertently sent the worn shoes to scrap, a further set (IMP-5 & 6 and DSS 5 & 6) were installed on the MV CANSO CONDOR which carried out one fishing trip in Area 4W. A lot of gear damage occurred on this trip, during which the actual fishing time was 132 hours (5½ days). All four of the shoes were replaced after this trip and have been returned to Dr. Davis.

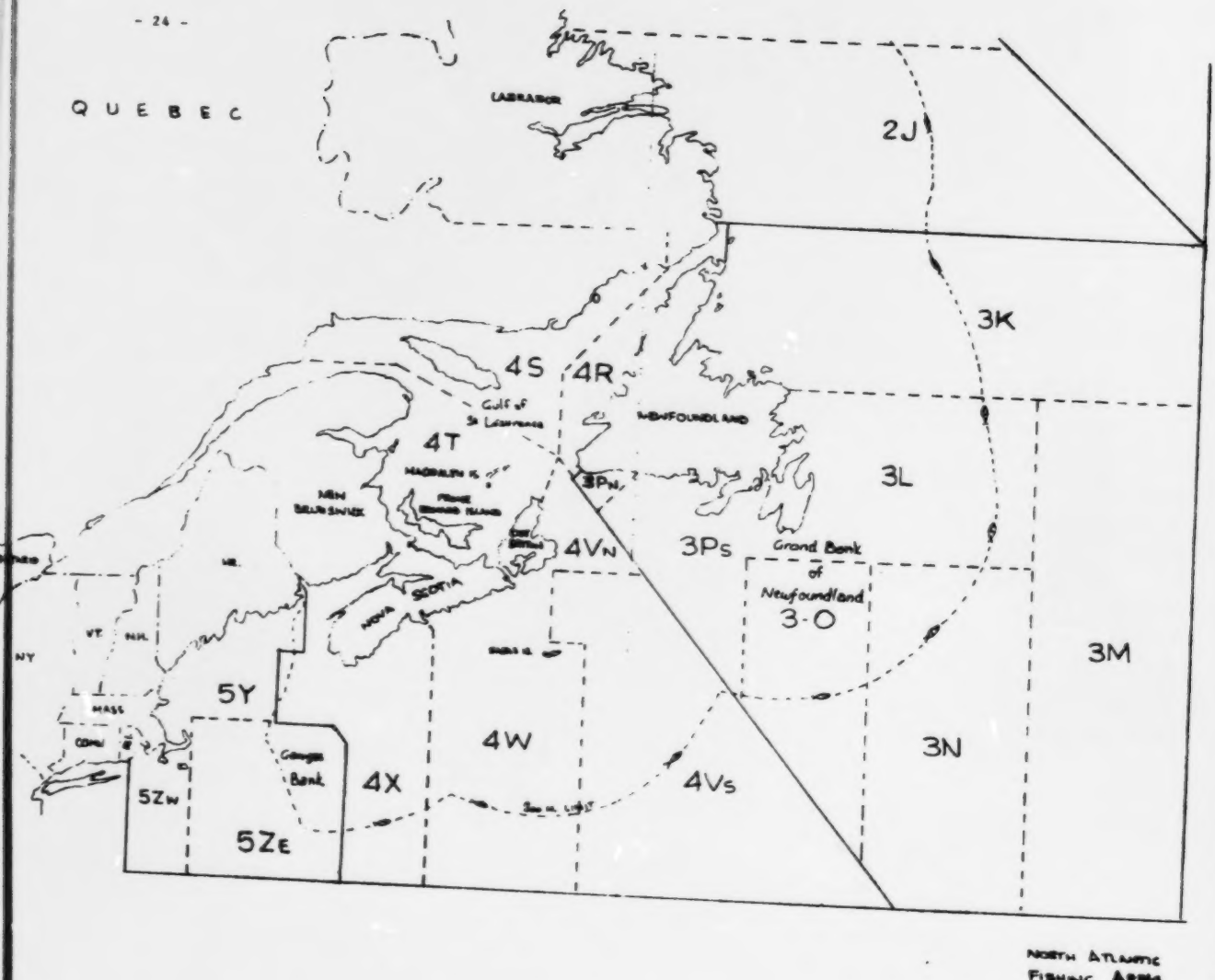
The user's comments on the Canmet shoes were sought and in general he was not favourably impressed with their performance. He was concerned that they broke fairly easily and although he achieved quite similar usage times with both types of shoe when the Canmet did not break, he felt that, once the hard surface of the Canmet had been worn through, deterioration of the shoe was extremely rapid, whereas the standard shoe wore at a uniform rate and its condition at the end of a run was therefore much more predictable. Hence, if the cost of the two shoes were the same, he would choose the standard shoe.

However, it is considered that these trials do not necessarily rule out the Canmet shoe, or a modified version of it, for trawl doors. It is hoped that the trial may indicate what changes might be made to produce a more suitable unit for this particular application.

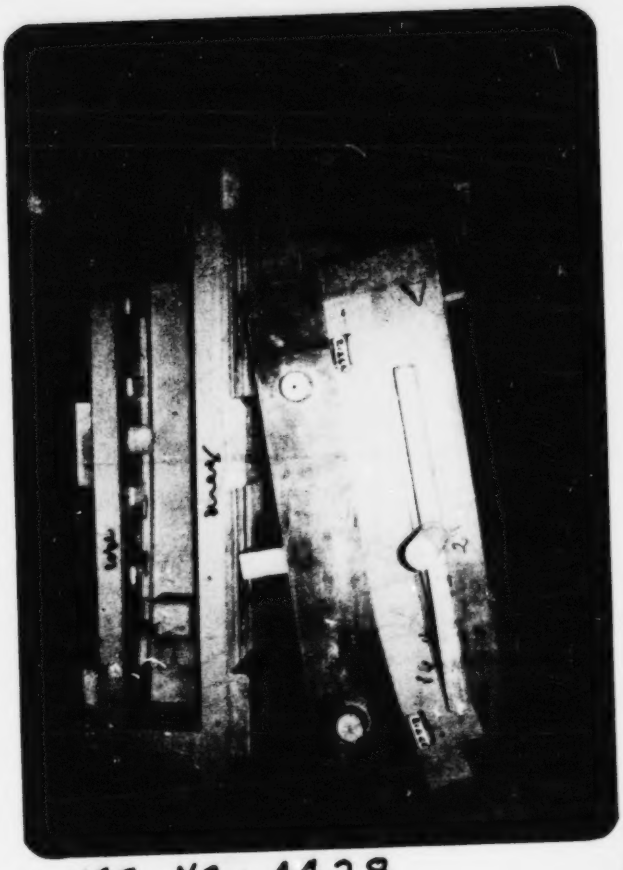


Polyvalent Trawl door

TRAWL DOOR SHOWING
LOCATION OF TEST SHOES



NORTH ATLANTIC FISHING AREAS



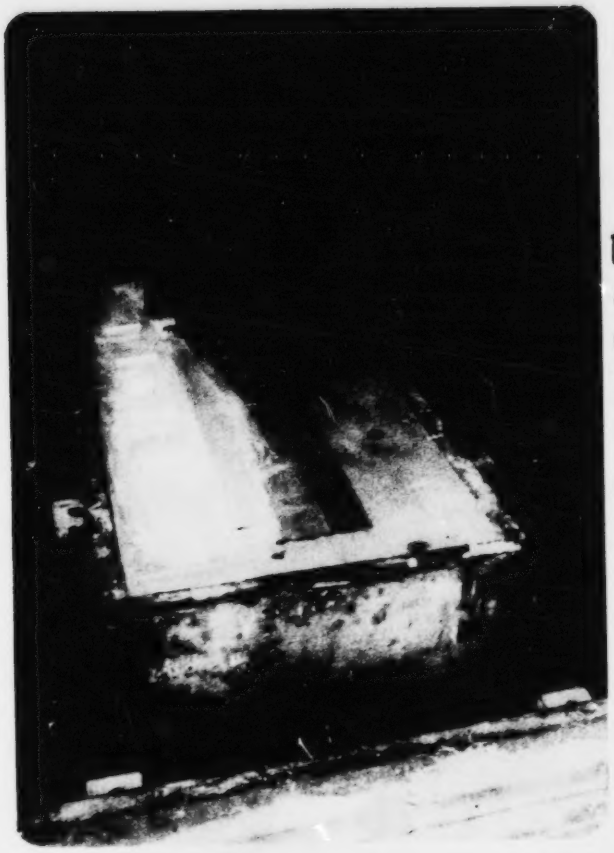
Core Box

Pattern

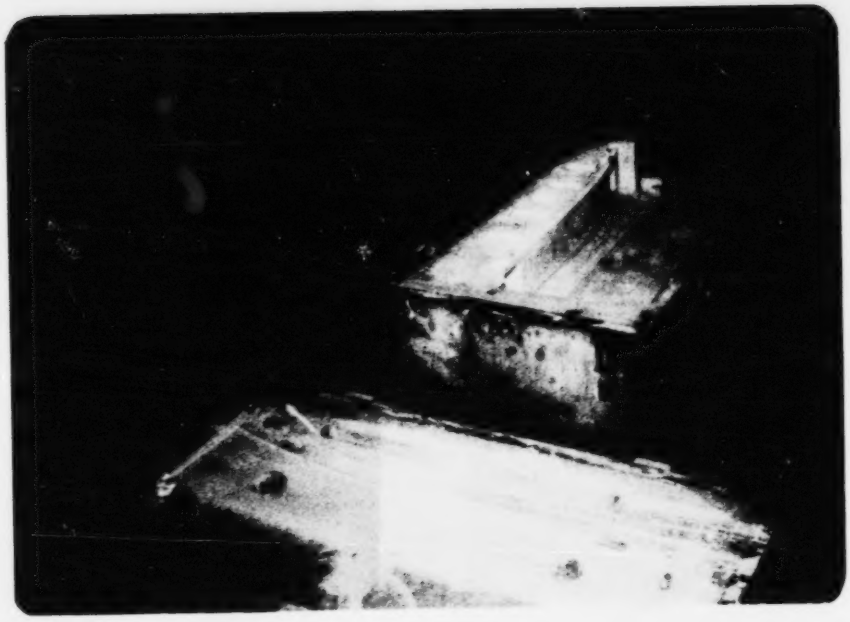
NEG NO. 4428

Assembled Vacuum Manifold with CrC Powder in place. Light area is core wash.

NEG NO 4427



Drag with core set in place ready to accept Vacuum Manifold prior to closing of mould Lighter area is core with wash applied.



Drag with core set in place

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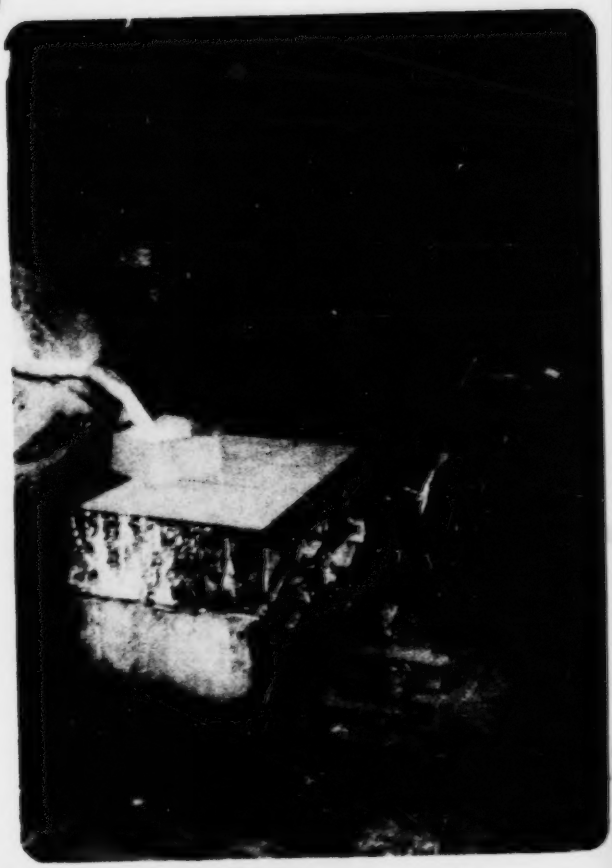
Assembled Mould
Note Vacuum Hook
Up.

NEG NO 4429

Pouring Mould while
under vacuum.



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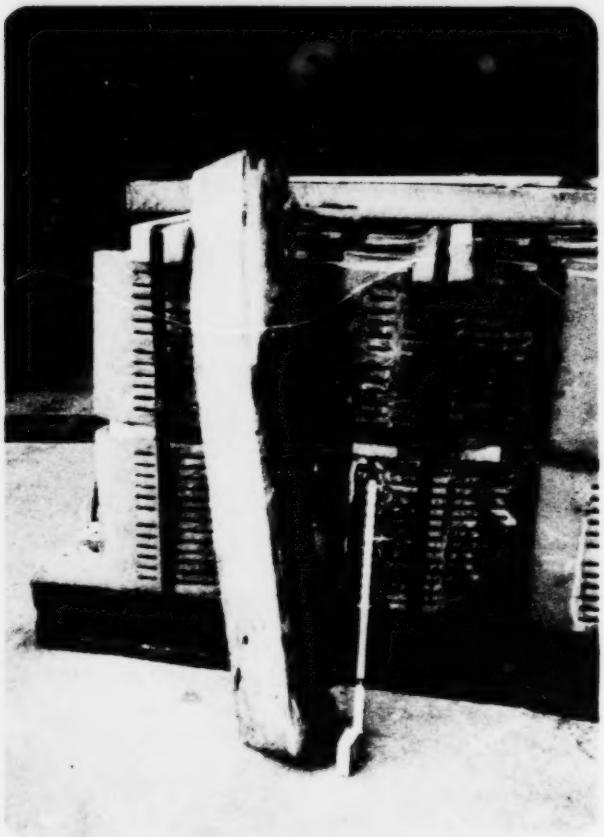
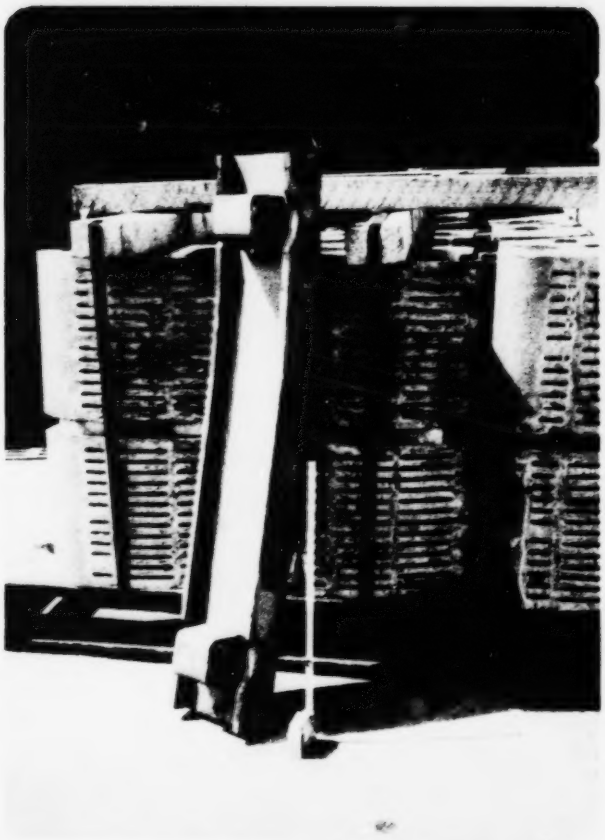


Carbide layer wear surface

NEG NO 4431

Top View of Dragger Shoe



NEG NO 4426